OPERATING AND SERVICE DATA
FOR
GMC MODEL 467A
DIGITAL THERMOELECTRIC POWER METER

MP MASTER
MA31504

GENERAL MICROWAVE CORPORATION

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FOR
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GENERAL MICROWAVE CORPORATION
155 MARINE STREET
FARMINGDALE, NEW YORK 11735

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SECTION I - INTRODUCTION

1.1 DESCRIPTION

1.2 The GMC Model 467A Digital Thermoelectric Power Meter in conjunction with any GMC tft® Power Head, is a highly accurate instrument for measuring radio-frequency power over an extremely wide frequency and power range. The Model 467A will measure and indicate the average power absorbed by the power head from CW, amplitude, frequency, and pulse modulated signals. The Model 467A, when operated with the GMC 420 Series tft Power Heads, yields superior thermal stability and low noise characteristics over a 10 nanowatt to 3 watt power range. Table 1.1 lists power head characteristics.

1.3 The Model 467A automatic scale selection feature ensures that only the scale corresponding to the sensitivity of the power head in use is activated. Other special features include a switch for selection of either normal or fast amplifier response time, an output jack for measurement systems using external recorders, and an optional 1-2-4-8 binary coded decimal output capability.

1.4 The Model 467A is suitable for use in diverse applications including fixed station and laboratory bench setups. Since all GMC Power Heads will operate with the Model 467A, a single instrument with different power heads can be applied to a wide variety of measurement applications. An optional junction box, GMC Model 963R, permits

® Thin-film thermoelectric.

Table 1.1 - Characteristics of tft Power Heads

SERIES	FREQUENCY RANGE (GHz)	AVERAGE** POWER RANGE FROM	AVERAGE** POWER RANGE TO	MAX. PEAK POWER (WATTS)	MAX. VSWR	WAVEGUIDE TYPE	CONNECTOR TYPE
N420	0.10-12.4	0.1 uW	10 mW	3	1.5***	Coaxial	N Male
N421		1.0 uW	100 mW	30			
N422		0.01 uW	1 mW	0.3			
N423		0.1 mW	3 W	100	1.5+		
N430		10 uW	10 mW	3	1.5***		
N431		0.1 mW	100 mW	30			
N432		1.0 uW	1 mW	0.3			
N440	0.01-18.0	0.1 uW	10 mW	1	1.35++	Coaxial	N Male
P440							APC-7
440	0.01-22.0						SMA Male
N441	0.01-18.0	1.0 uW	100 mW				N Male
P441							APC-7
441	0.01-22.0						SMA Male
X420	8.2-12.4	0.1 uW	10 mW	3	1.5	RG-52/U	UG-39/U
U420	12.4-18.0			3		RG-91/U	UG-419/U
K420	18.0-26.5			0.5		RG-53/U	UG-595/U
A420	26.5-40.0			0.5	1.65	RG-96/U	UG-599/U

**While the tft power heads will take overloads of up to 300% for short periods of time, extended periods of operation at this level, or exceeding these ratings, may result in either a permanent change in the tft element characteristics, or even a burnout. Maximum care should be exercised to avoid this occurrence.

***Except in the range from 10 to 15 MHz where VSWR may rise to 1.75.

+Except in the range from 10 to 15 MHz where VSWR may rise to 1.75 and in the range from 11.5 to 12.4 GHz where VSWR may rise to 2.0.

++Except in the range from 10 to 15 MHz where VSWR may rise to 1.5 and in the range from 10 GHz through the upper frequency limit where VSWR specification is 1.6.

operation of up to five tft power heads with one Model 467A. Further, Models 963R can be cascaded to permit operation of an even greater number of tft power heads.

1.5 For those units supplied with the BCD option, the following outputs are available at the BCD output connector:

1.5.1 Pins 1-4: "Units" digits 1, 2, 4 and 8. A logic 1 level corresponds to the activated digit.

1.5.2 Pins 5-8: "Tens" digits 1, 2, 4 and 8. A logic 1 level corresponds to the activated digit.

1.5.3 Pins 9-12: "Hundreds" digits 1, 2, 4 and 8. A logic 1 level corresponds to the activated digit.

1.5.4 Pin 13: "Overrange". A logic 1 level indicates that the input power has exceeded the upper limit of the selected range.

1.5.5 Pin 14: "Polarity". A logic 1 level corresponds to a positive input signal.

1.5.6 Pin 15: "Hold". External shorting to pin 24 inhibits digital indication changes.

1.5.7 Pins 16-18: Measurement units (uW, mW and W, respectively). A logic 1 level corresponds to the activated measurement unit.

1.5.8 Pins 19-21: Decimal point position (.XXX, X.XX and XX.X,

respectively). A logic 1 level corresponds to the activated decimal point.

1.5.9 Pin 22: Conversion complete. A transition to logic 0 indicates new data available in the storage registers.

1.5.10 Pin 23: Not used.

1.5.11 Pin 24: Ground.

1.5.12 Pin 25: Not used.

Table 1.2 Specifications

FEATURE	DESCRIPTIVE DATA
Power Range	From 0.010 uW to 3.00 watts (-50 dBm to +35 dBm). Eight different ranges in four overlapping power scales, with full-scale readings of:

uW	mW	W
1.000	1.000	1.000
10.00	10.00	3.00
100.0	100.0	

Display	Digital type, direct-reading in power, 3-1/2 digits plus polarity indicator.
Temperature Coefficient	Less than 0.1% per degree C.
Accuracy	±0.5% of reading ±1 count (+10°C to +40°C).
Noise and Drift	Less than ±0.15% peak-to-peak of full scale on the lowest range (±0.3% peak-to-peak on highest sensitivity scale) at constant ambient; correspondingly less on higher ranges.
Recorder Output	Calibrated dc analog output, adjustable from 0 to -1V full scale.
BCD Output (Optional)	Standard 1-2-4-8 binary coded decimal output can be made available from rear-mounted connector.
Response Time	NORMAL position less than 1.5 seconds; FAST position, approximately 100 ms.
Zero Carryover	One-time zero set, holds for all ranges.
Input Power	115/230V ±10%, 50-400 Hz, 10 watts.
Input Connectors	Front panel mounted.
Dimensions	6.8"H x 7.8"W x 12.6"D.(173 x 198 x 320 mm).
Weight	9-1/2 lbs.(250 gm).

1.6 A GMC Model 983-1 Rack Adapter allows the Model 467A to be rapidly rack-mounted singly or with any other GMC unit packaged in the half-rack configuration.

1.7 Refer to tables 1.2 and 1.3 for additional data.

Table 1.3 - Optional Accessories

MODEL	DESCRIPTION
305B	Calibrator - Provides all required calibration voltages for the Model 467A.
963R	Junction Box - Each permits operation of up to five tft power heads with one Model 467A. They can be cascaded.
983-1	Rack Adapter (19") - Permits rack-mounting of the Model 467A by itself, with any other GMC unit packaged in the half-rack configuration, or with 7-25/32" wide half-rack units of other manufacturers.

SECTION II - OPERATION

2.1 OPERATING CONTROLS, INDICATORS AND CONNECTORS

Operating controls, indicators and connectors are located on both the front and rear panels. Those on the front panel are:

RANGE: A four-position push-button switch for selection of the desired operating power range. Eight different ranges in four overlapping scales are available. The scale corresponding to the sensitivity of the power head in use is automatically activated. The overlay markings indicate the maximum power measurable on the illuminated (manually-selected) range.

METER ZERO: A potentiometer used to electrically zero the instrument. Once set on the most sensitive meter range, it need not be adjusted when changing ranges.

INPUT: A ten-pin connector which provides all interconnections with the power head in use. On units so equipped, an identical connector, wired in parallel, is located at the rear. Either may be used.

LINE: A two-position switch which energized the Model 467A when in the ON position.

% OF FULL SCALE: An auxiliary analog indicating meter which simplifies system adjustments. Particularly useful when peaking power levels or when making frequency adjustments using cavity-type frequency meters.

The controls and connectors located at the rear of the Model 467A are:

115V-230V LINE. This switch allows operation with either 115 volt or 230 volt ac power. TO AVOID EQUIPMENT DAMAGE THE SWITCH MUST BE SET TO THE PROPER POSITION PRIOR TO APPLICATION OF POWER. If replacement of the associated fuse becomes necessary, ensure that the replacement conforms with the description given in the Table of Replaceable Parts.

OUTPUT. A calibrated analog output of the measured rf power (-1 volt dc full scale) or an adjustable dc output (0 to -1 volt full scale) is made available at these binding posts. A minimum value of load resistance is 1K ohm.

OUTPUT ADJUST. This potentiometer/switch controls the voltage available at the OUTPUT connector. When set to its detented position (fully clockwise) and with a full-scale meter indication, a -1 volt dc calibrated analog voltage is provided at the OUTPUT connector. When the control is not in the detented position, an adjustable linear 0 to -1 volt dc voltage proportional to the measured rf power is provided at the OUTPUT connector.

RESPONSE. This switch controls the amplifier response time. When in the NORM position, the response time of the amplifier will be less than 1.5 seconds and in the FAST position, about 100 ms. (Note, however, that the noise will also increase when in the FAST position, particularly in the lower ranges.)

INPUT. This connector (optional) parallels the INPUT connector on the front panel. Either may be used for interconnection with the power head in use.

BCD OUTPUT. This connector (optional) supplies the digital data corresponding to the measured rf input. Refer to paragraph 1.5 for details.

2.2 INSTALLATION AND OPERATING PROCEDURES

Special precautions to be observed when installing or using a Model 467A and GMC Series tft Power Heads, other than the normal good practices associated with accurate measurement procedures, and the use and handling of microwave components, are described in steps 2.2.1 and 2.2.2. In this respect, a warm-up period of about 15 minutes should be allowed before use, to permit circuit stabilization. The flange or connector of the power head should be handled with care to avoid scratching or marring the surfaces and connecting parts, and should be covered with a protective cap when not in use to prevent accumulations that can affect performance. Finally, power ratings of the power heads should never be exceeded since permanent damage to the tft element may result. Although the power ratings are conservatively applied, the margin of safety should not be deliberately narrowed.

To record a plot of power output versus time, use the OUTPUT connector and OUTPUT ADJUST control as described in paragraph 2.1.

To control the operation of the Model 467A from a remote location or to obtain outputs from the optional BCD OUTPUT connector, make the appropriate connections in accordance with paragraph 1.5.

To rack-mount the Model 467A, use a GMC Model 983-1 Rack Adapter.

To operate a Model 467A, proceed as follows:

2.2.1 TO AVOID PERMANENT DAMAGE TO THE INSTRUMENT, SET THE 115V-230V LINE SWITCH TO THE CORRECT POSITION.
Make the connection to the ac power source, and set the LINE switch to ON.*

2.2.2 Connect the power head to the INPUT connector. Do not connect the power head to the source of rf power at this point. CHECK THAT THE POWER HEAD USED CAN SAFELY HANDLE THE MAXIMUM EXPECTED RF INPUT POWER.

2.2.3 Set the Model 467A to its most sensitive range.

2.2.4 Determine the effective efficiency from the graph mounted on the power head and set the EFF control on the power head to the value obtained.

2.2.5 Allow a 15 minute warm-up period and zero the Model 467A using the METER ZERO control.

*Note that beat notes will arise between certain line frequencies and harmonics of the chopper frequency, producing erratic performance of the Model 467A. The forbidden line frequency bands are 53-57, 104-116, 162-168, 217-223, 272-278, 327-333, 382-388, 437-443, 492-498, 547-553, 602-608, 657-663, 712-718, 767-773, 822-828, 877-883, 932-938 and 987-993 Hz.

2.2.6 Depress the desired RANGE button, connect the power head to the source of rf power to be measured, and read the power on the digital display. (If the power to be measured is not approximately known, use the least sensitive power head available, and, after application of rf power, change power heads as required.)

2.3 MULTI-POINT TESTING WITH THE MODEL 467A

Since tft power heads are rf power-to-dc voltage transducers, it is possible to successively connect a number of different tft power heads to a Model 467A, thereby enabling measurement of power at different points in an rf network, without readjustment of the Model 467A. There is no danger of upsetting the network characteristics under these conditions, since tft power heads retain their matched characteristics, even when not connected to the Model 467A.

To facilitate the use of a number of power heads, a five-input junction box, Model 963R, is available. Switching is performed by a front-panel mounted low-noise rotary switch. By cascading junction box units, a larger number of power heads can be used in conjunction with one Model 467A.

To use the Model 467A in conjunction with a Model 963R, connect the 963R to the 467A, connect the power heads to the 963R, and proceed as follows with no rf inputs applied to the power heads:

2.3.1 Select any channel using the 963R SELECTOR switch.

2.3.2 Set the 963R METER ZERO control corresponding to the selected channel to approximately mid-range.

2.3.3 Zero the 467A using the METER ZERO control.

2.3.4 Sequentially select each of the other 963R channels in use and individually zero each channel using the corresponding 963R METER ZERO control.

SECTION III - THEORY OF OPERATION

3.1 GENERAL CIRCUIT DESCRIPTION

3.1.1 The Model 467A is basically a very low noise, high gain and high gain stability chopper-stabilized dc amplifier and a self-contained digital voltmeter (DVM). An auxiliary analog meter is included as an aid in making system adjustments.

3.1.2 Figures 3.1 and 3.2 are the block and schematic diagrams of the overall unit. Referring to the block diagrams, the dc input signal from the power head is applied to the modulator whose square-wave output signal is stepped-up by the input transformer and applied to the low-noise preamplifier. The amplified signal is then coupled to the filter amplifier, where much of the noise and other spurious signals are filtered out. The resulting sine-wave signal is amplified and phase-split prior to demodulation. The full-wave demodulator, which is synchronous with the modulator, recovers the input dc signal at a greatly amplified level.

3.1.3 The demodulator output is applied to the integrating amplifier for additional signal gain, and reduction of the required amplifier bandwidth to the degree required consistent with the selected response time (and noise level). The integrating amplifier output is then coupled back to the modulator and

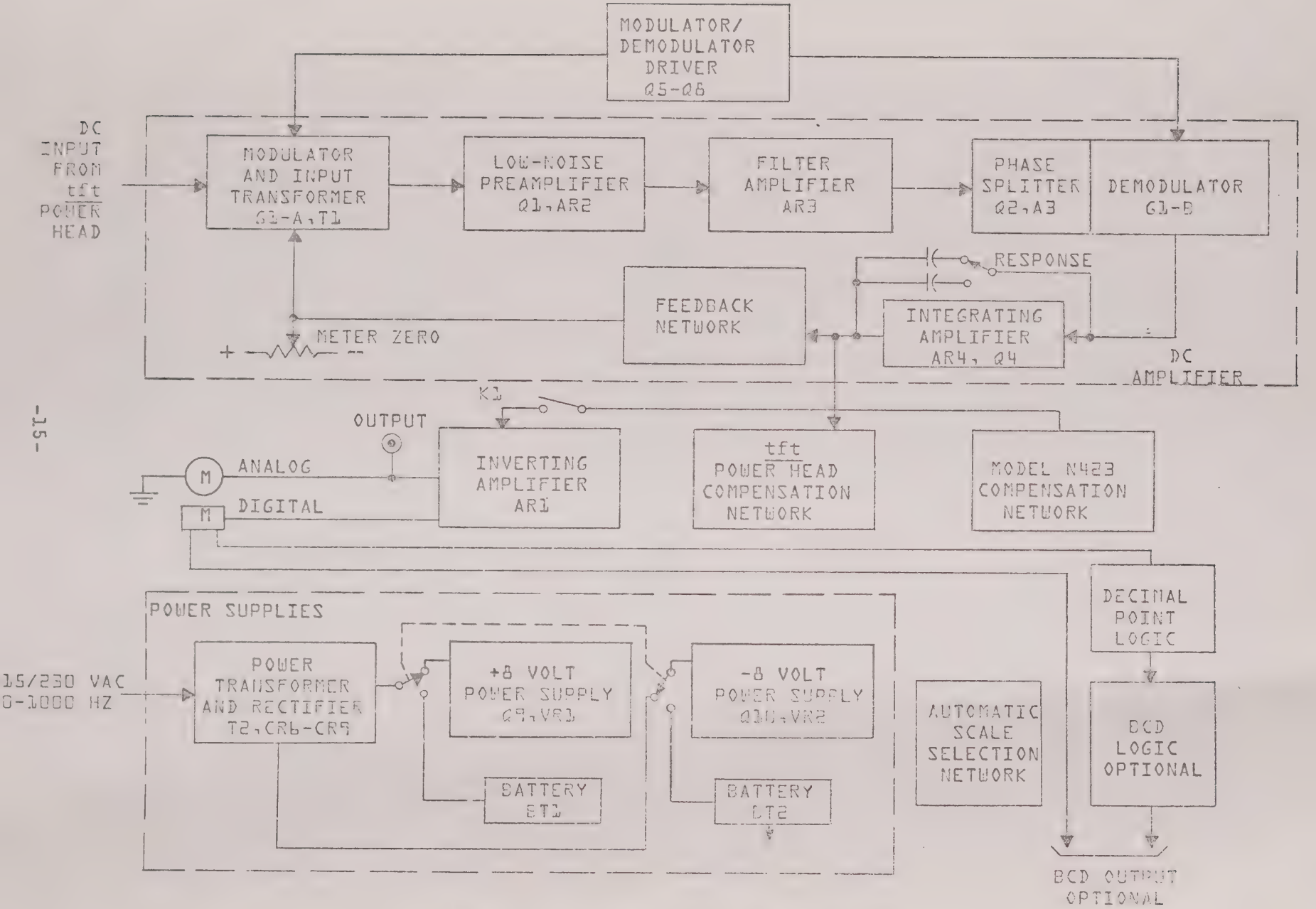


Figure 3.1 Model 487A Block Diagram

(For convenient use, the schematic diagram is located in Section V.)

Figure 3.2 Model 467A Schematic Diagram

input transformer circuit through a RANGE switch network. This degenerative feedback path provides a high degree of gain stability, and at the same time provides a means of accurate control of the overall amplifier gain.

3.1.4 The integrating amplifier output is also applied to a compensation network in the power head, where compensation is made for the sensitivity of the power head, and for its effective efficiency at the frequency of the signal under measurement. The return from the power head compensation network is applied to the inverting amplifier, and the output of this circuit drives the meters. The inverting amplifier output is also made available at the recorder/digital voltmeter OUTPUT jack J4.

3.1.5 Two identical 8-volt regulated power supplies are included in the Model 467A. One is connected as a positive source, and the other a negative.

3.1.6 Operation of the automatic scale selection network is controlled by the various interlock combinations associated with pins 4, 5 and 6 of the tft power head connector.

3.1.7 The modulator/demodulator drive circuit is a conventional free-running multivibrator which provides the required 110 Hz signal.

3.1.8 The Model 467A contains a non-linearity compensation network for

the GMC Model N423 tft Power Head when measuring power levels in excess of 1.0 watt.

3.1.9 The DVM employs an integrating technique to display in decimal form the output of the inverting amplifier.

3.2 DETAILED CIRCUIT DESCRIPTION (REFER TO FIGURE 3.2)

3.2.1 DC AMPLIFIER

3.2.1.1 MODULATOR AND INPUT TRANSFORMER. The input signal to the Model 467A is applied to the moving arm of modulator G1-A, which is one-half of a mechanical chopper. The dc amplifier feedback signal and the dc offset voltage from the METER ZERO control R23 are applied to the center-tap of the primary of input transformer T1. Therefore, the difference between the input and feedback signals are alternately applied to each half of the transformer primary, producing a chopped signal (square-wave). This signal, stepped up in the transformer, is applied to low-noise preamplifier, Q1 and AR2.

To eliminate thermal emf's in the input circuit, copper leads are employed throughout, and all connections are soldered with low-thermal-emf solder. The modulator and input transformer also employ copper leads, and the transformer is carefully shielded to minimize hum pickup. The input connector employs special pins for the signal lines.

3.2.1.2 LOW-NOISE PREAMPLIFIER. The square-wave signal from the modulator and input transformer is amplified in the Q1 and AR2 stages, and coupled to the filter amplifier. The gain of the AR2 stage is controlled by resistor R12, R14, R16 and R18, and is determined by the RANGE switch setting.

3.2.1.3 FILTER AMPLIFIER. The square-wave signal from the low-noise preamplifier is amplified in the AR3 stage, which is an active bandpass amplifier/filter network centered at 110 Hz. Fine tuning for the stage is provided by means of potentiometer R39.

3.2.1.4 PHASE SPLITTER AND DEMODULATOR. The signal from the filter amplifier is applied to phase splitter Q2 which, together with Q3, drives the demodulator G1-B. The full-wave demodulator is synchronously driven with the modulator at a 110 Hz rate, thereby effectively eliminating non-synchronous noise and spurious signals present in the carrier.

3.2.1.5 INTEGRATING AMPLIFIER. The output of the demodulator is applied to AR4 which, together with Q4, feedback resistor R57, and feedback capacitor (C32 or C33), forms an integrating amplifier. This feedback capacitor determines the bandwidth of the dc amplifier, and is controlled by the setting of the RESPONSE switch S2. When in the NORM position, the response time of the Model 467A is less than 1.5 seconds, and the noise is less than $\pm$0.3% peak-to-peak of full scale on the most

sensitive range. When the RESPONSE switch is set to FAST, the response time decreases to approximately 100 milliseconds, but the noise may increase above the ±0.3% specification, particularly on the lower ranges.

3.2.1.6 FEEDBACK NETWORK. The integrating amplifier dc output provides the feedback signal around the entire dc amplifier. The magnitude of the feedback signal, and therefore, the dc amplifier gain, is determined by the ratio of the sum of resistors R11, R13, R15 and R17 (which, in turn, depends on which of the four ranges has been selected), to the value of resistor R26.

The presence of spurious dc signals at the input to the dc amplifier must be anticipated due to thermal emf's, and any slight unbalances that may be present in the power head. Accordingly, to correct for these offset signals, a small adjustable dc voltage is introduced with the feedback signal. This voltage is derived from the positive and negative power supplies and is controlled by the setting of the METER ZERO potentiometer R23.

3.2.2 tft POWER HEAD COMPENSATION NETWORK.

The integrating amplifier dc output is also applied to the compensation network in the power head. Adjusting the sensitivity and efficiency controls in the power head (see

calibrate procedure for the power head) normalizes the gain of AR1 in the Model 467A. As a result the Model 467A can be used, without adjustment, with any GMC tft Series Power Head.

3.2.3 INVERTING AMPLIFIER

The compensated return from the power head is amplified and inverted in the AR1 stage. Potentiometer R1 is a dc offset adjustment for the stage. The output of AR1, which is an analog voltage varying from 0 to -1 volt as a function of the measured rf power level, is applied to the front-panel meter M2, the OUTPUT jack J4, and the DVM. The signal level at the OUTPUT jack can be conveniently adjusted for recorder use by means of the ADJUST potentiometer R25, or alternately, can be maintained at a -1 volt full scale level for external use or calibration purposes by rotating the ADJUST potentiometer fully clockwise to its detented position. This closes switch S4, thereby shorting out potentiometer R25.

3.2.4 POWER SUPPLIES

Two identical regulated 8 volt power supplies are included in the Model 467A. The positive supply consists of Q9 and VR1, and associated components. The full-wave rectified output of CR6 and CR7, at about 18 volts, is applied to current booster Q9. The output of Q9 is applied to the voltage regulator VR1, and the regulated +8 volt output is distributed throughout the

Model 467A. The negative power supply consisting of CR8, CR9, Q10, VR2 and associated components provides the required -8 volt output.

3.2.5 AUTOMATIC SCALE SELECTION NETWORK

This network consists of transistors Q11 through Q13 (corresponding to the 1, 10 and 100 mW power heads, respectively), transistor Q14 (corresponding to the 3 watt Model N423 tft Power Head), emitter-follower Q15, and associated circuitry. Transistors Q11, Q12 and Q13 are normally biased "on", thereby establishing a potential at their collectors which is essentially at ground level. When any power head (except the N423) is connected to the Model 467A, two of the three interlock pins (4, 5 and 6) are grounded by the power head. These grounded pins bias two of the corresponding transistors "off". The remaining "on" transistor activates the corresponding column of indicator lamps (vertical). When a RANGE button is depressed, a positive potential is applied to the row of indicator lamps corresponding to the selected range (horizontal), and, therefore, only the single lamp corresponding to both the selected range and scale will go on since it is the only one which receives both the ground and positive potentials. Transistor Q14 is normally biased "off" when any power head (except the N423) is connected due to the clamping action of any grounded diode CR13,

CR14 or CR15. When a Model N423, which does not ground the interlock pins, is used, transistor Q14 will be biased "on" since neither CR13, CR14 or CR15 is grounded. This establishes the activating ground potential at the collector of Q4, and, therefore, on indicator lamps DS26, DS27, DS29 and DS31. This also establishes a negative potential at the base and emitter of Q15, which, in turn, clamps the bases of Q11, Q12 and Q13 at a negative potential, thereby biasing them "off". This removes the activating ground potential from the other three scales. (Note: With no power head connected the 3 watt scale is activated.)

3.2.6 MODULATOR/DEMODULATOR DRIVER

This circuit, consisting of Q5 - Q8 and associated components, is an astable multivibrator which is adjusted by potentiometer R35 for operation at 110 Hz. The output of Q6 and Q8 is applied directly to the chopper drive coil, G1.

3.2.7 MODEL N423 NON-LINEARITY COMPENSATION NETWORK

This network consists of diode CR5, relay K1 and resistor R45. When a Model N423 is connected to the Model 467A and the 3W RANGE button is depressed, relay K1 is energized, and the compensation network reduces the gain of amplifier AR1. The circuit parameters are such that proper compensation for the non-linearity of the Model N423 results, and the correction factor described in the Model N423 literature need not be applied.

3.2.8 DECIMAL POINT SELECTION

The decimal point selection circuit shown in figure 3.2 (sheet 3) provides appropriate decimal point location data to the DVM, the optional BCD OUTPUT connector and the logic assembly. This assembly contains a group of common-collector amplifiers A101 and A102 functioning as logical elements and a TTL hex inverter A103. The logic function implemented conforms to the truth table shown in table 3.1 for decimal point illumination. Circuitry is minimized by decoding DP-1 and DP-10 directly, and generating DP-100 indirectly by recognizing that DP-100 must be illuminated if, and only if, neither DP-1, nor DP-10 are decoded. The selected range signal from S1 is applied to the base, and the selected scale signal from the lamp assembly is applied to the emitter of a single transistor within A101 or A102. The collectors of all the transistors within A101 are common and are pulled up through R106 to positive 4.5 volts. A transistor is enabled and a ground potential appears at the corresponding A101 or A102 output pin, only if that transistor's base is driven positive while its emitter is held at ground potential. Transistors Q13, Q14 and Q15 perform decoding, driving and interface functions to illuminate the appropriate decimal point in the DPM. A103 inverts the decoded DP-1 and DP-10 signals and buffers the decimal point data for BCD output use.

3.2.9 BCD LOGIC (OPTIONAL)

The BCD logic circuitry provides the appropriate uW, MW and W data at the BCD output connector. Transistors Q201 and Q205 perform decoding functions on the range and scale data as shown in table 3.1 in a manner similar to that performed by the decimal point selection logic.

Table 3.1 Truth Table

Power Head Full Scale	Interlock Pins*			Range				Measurement Units			Decimal Points			Full-Scale Indication
	4	5	6	D**	F	H	K***	uW	mW	W	DP-100	DP-10	DP-1	
3W (DD)	1	1	1	1	0	0	0	0	0	1	0	1	0	3.00
				0	1	0	0	0	0	1	0	0	1	1.000
				0	0	1	0	0	1	0	1	0	0	100.0
				0	0	0	1	0	1	0	0	1	0	10.00
100 mW (CC)	0	1	0	1	0	0	0	0	1	0	1	0	0	100.0
				0	1	0	0	0	1	0	0	1	0	10.00
				0	0	1	0	0	1	0	0	0	1	1.000
				0	0	0	1	1	0	0	1	0	0	100.0
10 mW (BB)	0	0	1	1	0	0	0	0	1	0	0	1	0	10.00
				0	1	0	0	0	1	0	0	0	1	1.000
				0	0	1	0	1	0	0	1	0	0	100.0
				0	0	0	1	1	0	0	0	1	0	10.00
1 mW (AA)	1	0	0	1	0	0	0	0	1	0	0	0	1	1.000
				0	1	0	0	1	0	0	1	0	0	100.0
				0	0	1	0	1	0	0	0	1	0	10.00
				0	0	0	1	1	0	0	0	0	1	1.000

*0 indicates pin shorted to ground
**Least sensitive
***Most sensitive

SECTION IV - MAINTENANCE

4.1 GENERAL PARTS INFORMATION

Standard readily available components are used in the manufacture of GMC instruments wherever possible. Such parts can usually be obtained from a local dealer. Special or modified parts, as determined by an entry in the last column of the Table of Replaceable Parts, are available from GMC.

When ordering parts from GMC, please indicate your instrument model and serial number, plus the data given in the Table of Replaceable Parts.

4.2 INSTRUMENT REMOVAL

To remove the panel-chassis assembly from its cabinet, remove the ac line cord, the two screws at the rear of the unit and the two screws at the bottom of the unit. Carefully withdraw the panel-chassis assembly from the cabinet.

4.3 EQUIPMENT REQUIRED FOR TEST AND CALIBRATION

Use the test equipment listed in table 4.1 or equivalents in the performance of the test and calibration procedures.

Table 4.1 Required Test Equipment

DESCRIPTION	MFR.	MODEL
Calibrator	GMC	305B
Oscilloscope	Tektronix	503
Digital Multimeter	Fluke	8000A
Electronic Counter	H-P	5301A
Variable Autotransformer	Superior Electric	116
Ac Voltmeter	GE	AO-91

4.4 SPECIAL MAINTENANCE PRECAUTIONS

4.4.1 Do not make resistance or continuity checks on input transformer T1 or any transistor or integrated circuit with any ohmmeter that can supply more than 2 ma into a short-circuit. Use the DVM (or equivalent) suggested in Table 4.1.

4.4.2 Because of the very low dc voltages involved, repair of the Model 467A must be conducted with special care. All connections to the input circuit must be made with unplated copper leads only, and all solder connections must be made with low-thermal solder using a soldering iron with an unplated copper tip which has been employed only with that type of solder. A length of low-thermal solder is furnished with each Model 467A.

4.5 TURN-ON

4.5.1 With the line cord disconnected from any source of ac power, set the LINE switch to ON and make continuity checks to ensure that neither side of the ac line is connected to the chassis.

4.5.2 Set the Model 467A 115V-230V LINE switch to 115V and the RESPONSE switch to NORM.

4.5.3 Connect the Model 467A through the variable autotransformer to a source of 60 Hz power. Adjust the ac input to the Model 467A to 115 volts. (Use the ac voltmeter when making all input voltage adjustments throughout this test procedure.)

4.5.4 Connect the calibrator to the INPUT connector. Depress the calibrator ZERO and ON/OFF buttons.

4.5.5 Energize the power meter. The digital indicators should go on. Allow a 15 minute warm-up period before proceeding.

4.6 POWER SUPPLY TESTS

4.6.1 +8 VOLT POWER SUPPLY REGULATION TESTS

4.6.1.1 Adjust the line voltage to 103 volts.

4.6.1.2 Using the dc voltmeter, verify that the voltage between TP4 (+) and ground is between 7.5 and 8.4 volts.

4.6.1.3 Adjust the line voltage to 127 volts, and verify that the dc voltmeter indicates within 80 mV of the voltage measured in step 4.6.1.2.

4.6.2 -8 VOLT POWER SUPPLY REGULATION TESTS.

4.6.2.1 Connect the dc voltmeter between TP3 (-) and ground, and verify that it indicates between -7.5 and -8.4 volts.

4.6.2.2 Adjust the line voltage to 103 volts, and verify that the dc voltmeter indicates within 80 mV of the voltage measured in 4.6.2.1.

4.6.3 POWER SUPPLY RIPPLE TESTS.

4.6.3.1 With the line at 103 volts, check that the peak-to-peak ripple as observed on the oscilloscope between TP4 and ground does not exceed 1 mV.

4.6.3.2 Repeat step 4.6.3.1 at TP3.

4.7 SENSITIVITY SELECTION LOGIC TEST

4.7.1 Depress the calibrator 1 mW button.

4.7.2 Depress the upper RANGE button on the unit under test and verify that the associated dc indicator lamp lights and that the digital indicator decimal point location is correct (.XXX).

4.7.3 Repeat step 4.7.2 for all possible combinations using the three other settings of the calibrator power head rating switch, and the three other RANGE buttons on the unit under test as tabulated below:

1 mW .XXX	10 mW X.XX	100 mW XX.X	3 W X.XX
100 uW XX.X	1 mW .XXX	10 mW X.XX	1 W .XXX
10 uW X.XX	100 uW XX.X	1 mW .XXX	100 mW XX.X
1 uW .XXX	10 uW X.XX	100 uW XX.X	10 mW X.XX

4.8 CARRIER FREQUENCY TESTS AND ADJUSTMENTS

4.8.1 CHOPPER DRIVE FREQUENCY TESTS.

4.8.1.1 Depress the calibrator 10 mW button.

4.8.1.2 Connect the electronic counter between TP2 and ground, and adjust potentiometer R35 for an indication on the electronic counter of 110 ±0.5 Hz. Remove the electronic counter.

4.8.2 FILTER ADJUSTMENT

4.8.2.1 With the Model 467A de-energized, remove integrated circuit AR4 from its socket.

4.8.2.2 Connect the oscilloscope between TP1 and ground. Depress the 10 mW RANGE button on the Model 467A.

4.8.2.3 Turn the Model 467A ON and adjust potentiometer R39 for a symmetrical negative-going, full-wave rectified sine wave with a notch centered between the negative going pulses as shown adjacent to TP1 on figure 3.2. De-energize the Model 467A and replace AR4.

4.9 INDICATOR CALIBRATION

4.9.1 DC ZERO ADJUSTMENT.

4.9.1.1 Turn the Model 467A on. Connect the dc voltmeter to the OUTPUT connector on the rear of the instrument.

4.9.1.2 Rotate the OUTPUT ADJUST control fully clockwise to its detented position.

4.9.1.3 Adjust potentiometer R1 for a 0 $\pm$0.3 mV indication on the dc voltmeter.

4.9.1.4 Depress the 10 mW RANGE button on the unit under test and adjust the METER ZERO control for a 0 $\pm$5 mV indication on the dc voltmeter.

4.9.1.5 Continue to repeat steps 4.9.1.3 and 4.9.1.4 until no additional adjustments are required.

4.9.2 DIGITAL INDICATOR CALIBRATION

4.9.2.1 Remove digital indicator's polarized viewing filter to gain access to the zero set and cal adj potentiometer.

4.9.2.2 Depress the 10 mW RANGE button on the unit under test.

4.9.2.3 Release the calibrator ZERO button and depress its POWER RANGE 2 button.

4.9.2.4 Adjust zero set potentiometer located at top center of indicator for a digital indication of 0.001.

4.9.2.5 Depress the calibrator POWER RANGE 8 button.

4.9.2.6 Adjust cal adj potentiometer located to left of zero set for a digital indication of 10.00.

4.9.2.7 Continue to repeat steps 4.9.2.3 through 4.9.2.6 until additional adjustments are no longer required to obtain the specified potentiometer settings.

4.9.3 ANALOG INDICATOR (% OF FULL SCALE) CALIBRATION

4.9.3.1 Depress the calibrator POWER RANGE 8 button.

4.9.3.2 Adjust potentiometer R21 for an indication of 100 on the analog meter.

4.10 RANGE-TO-RANGE ACCURACY TESTS

4.10.1 Set the Model 305B calibrator and Model 467A controls in accordance with the tabulation given below. Verify that the digital display indications and the dc voltmeter indication where applicable, are in accordance with the limits shown. At each range setting, re-check the Model 467A zero.

Table 4.2 Range-to-Range Accuracy

Depressed Model 467A Range Button	Depressed Model 305B Power Range Button	Digital Display		DC Output Limits (V)		Depressed Model 305B Power Rating Button
		From	To	From	To	
10 uW**	2	9.94*	10.06*	0.995	1.005	10 mW
100 uW	4	99.4*	100.6*	0.995	1.005	10 mW
1 mW	6	0.994*	1.006*	0.995	1.005	10 mW
10 mW	8	9.94*	10.06*	0.995	1.005	10 mW

*Plus or minus 1/2 count (i.e. - an indication flashing between 994 and 993 or 1006 and 1007 is acceptable).

**Due to the presence of noise and drift on this sensitive range, the test should be repeated several times and an average reading determined.

4.10.2 Depress the POWER RANGE 7 and 3 W buttons on the calibrator, and the 3 W RANGE button on the Model 467A. Check that the digital display indication is between 2.96 and 3.04, ±1/2 count.

4.11 ZERO CARRYOVER TEST

4.11.1 Depress the calibrator ZERO button.

4.11.2 Depress the 10 uW RANGE button on the unit under test.

4.11.3 Using the METER ZERO control, adjust for a digital indication of 0.00.

4.11.4 Sequentially depress each of the remaining three RANGE buttons on the Model 467A and verify that zero digital indications are obtained in each position.

4.12 RESPONSE TIME TEST

4.12.1 Connect the oscilloscope to the OUTPUT connector.

4.12.2 Depress the 10 uW RANGE button on the Model 467A.

4.12.3 Release the calibrator ZERO button and depress the POWER RANGE 2 button.

4.12.4 Set the oscilloscope sensitivity and sweep rate to 0.5 V/CM and and 0.5 SEC/CM, respectively.

4.12.5 Depress the calibrator ZERO button.

4.12.6 Adjust the METER ZERO control for a digital indication of 0.00.

4.12.7 While observing the oscilloscope, verify that the rise time (10% to 90%) of the waveform is between 0.5 and 1.5 seconds after the ZERO button is released.

4.12.8 Set the RESPONSE switch to FAST and repeat steps 4.12.5 and 4.12.6.

4.12.9 Set the oscilloscope sweep rate to 0.1 SEC/CM and repeat step 4.12.7. The rise time should be between 50 and 150 milliseconds. Reset the RESPONSE switch to NORM.

4.13 NOISE TEST

4.13.1 Using the METER ZERO control, adjust for a digital indication of 1.00 uW.

4.13.2 Observe the total peak-to-peak digital indicator change over a period of about 10 seconds. It should not vary by more than 0.03 uW peak-to-peak.

4.14 OUTPUT ADJUST TEST

4.14.1 Depress the 10 mW RANGE button on the unit under test.

4.14.2 Depress the calibrator POWER RANGE 8 button and release its ZERO button.

4.14.3 Rotate the OUTPUT ADJUST control counterclockwise and verify that the indication on the oscilloscope varies from -1 volt to 0.

4.14.4 Rotate the OUTPUT ADJUST control fully clockwise to its detented position.

4.15 BCD OUTPUT TEST

These tests are performed at the BCD output connector J201.

Depress the 10 mW button and POWER RANGE 4 button on the calibrator. Depress the 100 uW RANGE button on the Model 467A. Adjust METER ZERO control for displayed reading of 100.0.

4.15.1 Connect a jumper between pins 15 and 24 on BCD connector to put unit in HOLD. Check that the held display is 100.0.

4.15.2 Measure the BCD output connector pins and verify that outputs are as given in table 4.3.

4.15.3 Temporarily release HOLD by removing jumper between 15 and 24. Adjust METER ZERO control for displayed reading of 99.9.

4.15.4 Place unit in HOLD by reconnecting jumper between pin 15 and 24.

4.15.5 Check output pins and verify that outputs are as given in table 4.3.

4.15.6 Release HOLD and depress 305B POWER RANGE 3. Adjust METER ZERO control for displayed reading of 33.3.

4.15.7 Place unit in HOLD.

4.15.8 Check BCD output per table 4.3.

4.15.9 Depress Model 467A RANGE button 1 mW and observe that BCD outputs are as given in table 4.3.

4.15.10 Depress Model 467A RANGE button 3W and 305B 3W button and observe that BCD outputs are as given in table 4.3.

Table 4.3 BCD Output

BCD OUTPUT PINS	Para 4.15.2 (100.0 uW)	Para 4.15.5 (99.9 uW)	Para 4.15.8 (33.3 uW)	Para 4.15.9 (.333 mW)	Para 4.15.10 (3.33 W)
1	0	1	1	1	1
2	0	0	1	1	1
3	0	0	0	0	0
4	0	1	0	0	0
5	0	1	1	1	1
6	0	0	1	1	1
7	0	0	0	0	0
8	0	1	0	0	0
9	0	1	1	1	1
10	0	0	1	1	1
11	0	0	0	0	0
12	0	1	0	0	0
13	1	0	0	0	0
14	1	1	1	1	1
16	1	1	1	0	0
17	0	0	0	1	0
18	0	0	0	0	1
19	0	0	0	1	0
20	0	0	0	0	1
21	1	1	1	0	0
22	0	0	0	0	0
24	gnd	gnd	gnd	gnd	gnd

NOTE: "0" corresponds to dc potential between 0 and .800 volts
"1" corresponds to dc potential greater than 2.4 but less than 5.0 volts

Table 4.4

Main Frame, Amplifier Board, and Power Supply Replaceable Parts

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
AR1-AR4	IC, AMPLIFIER; P/N U5B770939X (See Figure 4.3A for pin locations)	4	07263	
CR1-CR4	DIODE; TYPE 1N914	7	01295	
CR5	DIODE; P/N 5082-2900	1	28480	
CR6-CR12	DIODE; TYPE 1N2070	7	01295	
CR13-CR15	SAME AS CR1			
CR16, CR18, CR20, CR22, CR24, CR26, CR28, CR30, CR32, CR34, CR36, CR38, CR40, CR41, CR43, CR45	DIODE; TYPE 1N281	16	01295	
CR17, CR19, CR21, CR23, CR25, CR27, CR29, CR31, CR33, CR35, CR37, CR39, CR42, CR44	NOT USED			
C1	NOT USED			
C2	CAP, FXD, CERAMIC, 0.005 uF; P/N TG-D50	3	56289	
C3	CAP, FXD, CERAMIC, 200 pF; P/N DD-201	2	71590	
C4	CAP, FXD, CERAMIC, 0.01 uF; P/N TG-S10	8	56289	
C5	NOT USED			
C6	SAME AS C4			
C7	CAP, FXD, TANTALUM, 68 uF; P/N K68E10	1	31433	

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
C8	CAP, FXD, CERAMIC, 0.1 uF; P/N HY-320	3	56289	
C9	CAP, FXD, TANTALUM, 150 uF; P/N K150E6	1	31433	
C10	NOT USED			
C11	CAP, FXD, TANTALUM, 22 uF; P/N K22E10	2	31433	
C12	CAP, FXD, TANTALUM, 47 uF; P/N K47E6	1	31433	
C13	SAME AS C4			
C14	CAP, FXD, CERAMIC, .05 uF; P/N TG-S50	2	56289	
C15	NOT USED			
C16	SAME AS C2			
C17, C18	SAME AS C4			
C19	CAP, FXD, MYLAR, 0.1 uF; P/N DMF1P1-10	2	14655	
C20	NOT USED			
C21	SAME AS C19			
C22	CAP, FXD, CERAMIC, 500 pF; P/N CE-501	1	71590	
C23	CAP, FXD, CERAMIC, 20 pF; P/N DD-200	1	71590	
C24	SAME AS C4			
C25	NOT USED			
C26	SAME AS C11			
C27	NOT USED			
C28, C29	CAP, FXD, POLYESTER, 0.68 uF ±10%; P/N C281CH/A680K	2	73445	
C30	NOT USED			

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
C31	SAME AS C14			
C32	CAP, FXD, TANTALUM, 1 uF ±10%; P/N 150D105X9035A2	1	56289	
C33	CAP, FXD, TANTALUM, 39 uF ±10%; P/N 150D396X9020R2	1	56289	
C34	SAME AS C4			
C35	NOT USED			
C36	SAME AS C3			
C37	SAME AS C2			
C38	SAME AS C4			
C39	CAP, FXD, TANTALUM, 4.7 uF; P/N K4R7C35K	2	31433	
C40, C41	NOT USED			
C42	SAME AS C39			
C43	CAP, FXD, ELECTROLYTIC, 500 uF; P/N TL-1217	1	56289	
C44	CAP, FXD, ELECTROLYTIC, 1000 uF; P/N TVL-1230	2	56289	
C45	NOT USED			
C46	SAME AS C44			
C47, C48	CAP, FXD, CERAMIC, 47 pF ±5%; P/N 851000C0G0470J	2	72982	
C49	CAP, FXD, TANTALUM,4.7 uF; P/N K4R7W15	2	31433	
C50	SAME AS C8			

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
C51	SAME AS C49			
C52	SAME AS C8			
C53	CAP, FXD, TANTALUM, 33 uF, 15V; P/N 196D336X0015FB	1	56289	
DS1	NOT USED			
DS2, DS4, DS6, DS8, DS10, DS12, DS14, DS16, DS18, DS20, DS22, DS24, DS26, DS27, DS29, DS31	LAMP, INCANDESCENT	16	71744	
DS3, DS5, DS7, DS9, DS11, DS13, DS15, DS17, DS19, DS21, DS23, DS25, DS28, DS30	NOT USED			
F1	FUSE, 1/4A, SLO-BLO; P/N 313.250	1	75915	
G1	CHOPPER, ELECTRONIC	1	11332	3153M-6
J1	CONN, RECEPTACLE, ELECTRICAL	1	11332	2907B
J2	NOT USED			
J3	CONN, RECEPTACLE, ELECTRICAL; P/N 1061-5	1	87930	
J4	BINDING POST ASSY; P/N's 29-1 BLK, 29-1 RED AND 29B11-1	1	81073	
K1	RELAY, REED, 12V; P/N RA30191121	1	15636	
M1	NOT USED			

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
M2	METER	1	11332	5346F-5
M3	DIGITAL PANEL METER	1	11332	6G1213
P1-P3	CONN, RECEPTACLE, ELECTRICAL; P/N 225-21521-101	3	02660	
Q1-Q3	TRANS; TYPE PN4250	7	07263	
Q4	TRANS; TYPE 2N2222	1	04713	
Q5-Q8	SAME AS Q1			
Q9-Q10	TRANS; P/N 40391, OR TRANS; TYPE 2N4036, AND HEAT SINK; P/N NF205	2 2 2	02735 01295 05820	
Q11-Q15	TRANS; TYPE 2N5135	5	04713	
R1	RES, VAR, FILM 25K OHMS ±20%; P/N 360T253B	1	11236	
R2	RES, FXD, FILM, 475K OHMS ±1%; STYLE RN60C	1	91637	
R3	RES, FXD, FILM 681 OHMS ±1%; STYLE RN60C	1	91637	
R4	RES, FXD, WW, 2000 OHMS ±0.05%; STYLE RB56E	1	91637	
R5	RES, FXD, WW, 1000 OHMS ±0.05%; STYLE RB56E	1	91637	
R6	RES, FXD, COMP, 1500 OHMS ±5%; STYLE RC07	4	01121	
R7	RES, FXD, COMP, 51 OHMS ±5%; STYLE RC07	4	01121	
R8, R9	RES, FXD, FILM 100K OHMS ±1%; STYLE RN60C	3	91637	

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
R10	RES, FXD, FILM, 301 OHMS ±1%; STYLE RN60C	5	91637	
R11	RES, FXD, FILM, 2317 OHMS ±0.1%; STYLE RN60C	1	91637	
R12	RES, FXD, COMP, 100K OHMS ±5%; STYLE RC07	5	01121	
R13	RES, FXD, FILM 20.94K OHMS ±0.1%; STYLE RN60C	1	91637	
R14	RES, FXD, COMP, 10K OHMS ±5%; STYLE RC07	4	01121	
R15	RES, FXD, FILM 209.4K OHMS ±0.1%; STYLE RN60C	1	91637	
R16	RES, FXD, COMP, 1000 OHMS ±5%; STYLE RC07	1	01121	
R17	RES, FXD, FILM, 2.094 MEGOHMS ±0.1%; P/N 9852-2B	1	65092	
R18	RES, FXD, COMP, 100 OHMS ±5%; STYLE RC07	2	01121	
R19-R21	NOT USED			
R22	RES, FXD, FILM 1740 OHMS ±1%; STYLE RN60C	1	91637	
R23	RES, VAR, WW, 25K OHMS	1	11332	3982C-3
R24	RES, FXD, WW, 111.07 OHMS ±0.05%; STYLE RB56E	1	91637	
R25	RES, VAR, COMP, 1000 OHMS ±10%	1	11332	5243B-3
R26	RES, FXD, WW, 10 OHMS ±0.1%	1	11332	2643G
R27	RES, FXD, COMP, 16K OHMS ±5%; STYLE RC07	1	01121	

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
R28	SAME AS R8			
R29	RES, FXD, FILM,249K OHMS ±1%; STYLE RN60C	1	91637	
R30	RES, FXD, COMP, 110 OHMS ±5%; STYLE RC32	1	01121	
R31, R32	SAME AS R12			
R33	SAME AS R6			
R34	RES, FXD, COMP, 220K OHMS ±5%; STYLE RC07	1	01121	
R35	RES, VAR, FILM, 500 OHMS ±20%; P/N 360T501B	2	11236	
R36	SAME AS R7			
R37	RES, FXD, COMP, 470K OHMS ±5%; STYLE RC07	1	01121	
R38	RES, FXD, FILM, 3160 OHMS ±1%; STYLE RN60C	1	91637	
R39	SAME AS R35			
R40	RES, FXD, FILM, 150 OHMS ±1%; STYLE RN60C	1	91637	
R41	SAME AS R12			
R42	RES, FXD, FILM 634K OHMS ±1%; STYLE RN60D	1	91637	
R43	SAME AS R6			
R44	SAME AS R7			
R45	RES, FXD, FILM, 15.4K OHMS ±1%; STYLE RN60C	1	91637	

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
R46	RES, FXD, COMP, 68K OHMS ±5%; STYLE RC07	1	01121	
R47	RES, FXD, COMP, 24K OHMS ±5%; STYLE RC07	1	01121	
R48, R49	RES, FXD, COMP, 4700 OHMS ±5%; STYLE RC07	14	01121	
R50	RES, FXD, COMP, 47K OHMS ±5%; STYLE RC07	3	01121	
R51	RES, FXD, COMP, 3300 OHMS ±5%; STYLE RC07	1	01121	
R52	RES, FXD, COMP, 3900 OHMS ±5%; STYLE RC07	7	01121	
R53	SAME AS R50			
R54	SAME AS R12			
R55	SAME AS R14			
R56	SAME AS R50			
R57	RES, FXD, COMP, 4.7 MEGOHMS ±5%; STYLE RC07	1	01121	
R58	RES, FXD, COMP, STYLE RC07; SELECT VALUE AT TEST	1	01121	
R59	SAME AS R6			
R60	RES, FXD, COMP, 150 OHMS ±5%; STYLE RC07	1	01121	
R61	RES, FXD, COMP, 8200 OHMS ±5%; STYLE RC07	1	01121	
R62	SAME AS R7			
R63	RES, FXD, COMP, 200 OHMS ±5%; STYLE RC07	1	01121	

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
R64	SAME AS R18			
R65	SAME AS R48			
R66, R67	RES, FXD, FILM,1210 OHMS ±1%; STYLE RN60C	2	91637	
R68	SAME AS R48			
R69, R70	NOT USED			
R71	RES, FXD, COMP, 20 OHMS ±5%; STYLE RC07	1	01121	
R72, R73	RES, FXD, COMP, 1 OHM ±10%; P/N EB10G1	2	01121	
R74	RES, FXD, FILM,9090 OHMS ±1%; STYLE RN60C	2	91637	
R75	NOT USED			
R76	RES, FXD, FILM,2490 OHMS ±1%; STYLE RN60C	2	91637	
R77	SAME AS R74			
R78	SAME AS R76			
R79-R85	NOT USED			
R86	RES, FXD, COMP, 2000 OHMS ±5%; STYLE RC07	4	01121	
R87	SAME AS R52			
R88	SAME AS R86			
R89	SAME AS R52			
R90	SAME AS R86			
R91, R92	SAME AS R52			

Table 4.4 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
R93	SAME AS R86			
R94	SAME AS R52			
R95	RES, FXD, COMP, 6200 OHMS ±5%; STYLE RC07	1	01121	
R96	RES, FXD, COMP, 750 OHMS ±5%; STYLE RC07	1	01121	
S1	SWITCH, PUSHBUTTON, 4 STATION	1	5318-3	
S2	SWITCH, SPDT; P/N GF-324	1	79727	
S3	SWITCH DPDT; P/N GF-326 MODIFIED W/.031 SLOTTED KNOB	1	79727	
S4	PART OF R25			
S5	SWITCH, TOGGLE; P/N MST-1050 W/PLASTIC CAP C-10(BLACK) AND NUT N-1	1	95146	
TP1-TP4	TEST POINT; P/N 8436401-166G4	4	49956	
T1	TRANSFORMER, AUDIO FREQUENCY	1	11332	5047D-3
T2	TRANSFORMER, POWER	1	11332	4995-3
VR1-VR2	IC, VOLTAGE REGULATOR; P/N LM305A (See figure 4.3B for pin locations)	2	12040	
W1	AC CORD SET, 3 CONDUCTOR; P/N 17258	1	70903	

Table 4.5

Decimal Pt Logic Assy Components

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
A101, A102	IC AMPLIFIER P/N CA3082	2	02735	
A103	IC AMPLIFIER P/N SN7416N	1	12040	
C101	CAP, FXD, TANTALUM, 2.2 uF 35V P/N T330B225M035AS	1	31433	
CR101-CR105	DIODE, TYPE 1N277	5	01295	
Q113-Q115	TRANSISTOR, TYPE 2N4410	3	01295	
R101-R104, R112-R115	RES, FXD, COMP, 22K OHMS ±5%; TYPE RC07	8	81349	
R105, R109	RES, FXD, COMP, 10K OHMS ±5%; TYPE RC07	2	81349	
R106, R107, R110, R111	RES, FXD, COMP, 4700 OHMS ±5%; TYPE RC07	4	81349	
R108	RES, FXD, COMP, 3900 OHMS ±5%; TYPE RC07	1	81349	

Table 4.6

BCD Logic Assy Components (Optional)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
A201	IC, AMPLIFIER P/N SN15837N	1	01295	
C201	CAP, FXD, TANTALUM, 2.2 uF, 35V P/N T330B225M035AS	1	31433	
CR201-CR208	DIODE, TYPE 1N277	8	01295	
J201	CONNECTOR, RECEPTACLE ELECTRICAL P/N DBM-25S	1	71468	

Table 4.6 (Cont)

REF DES	DESCRIPTION	TOTAL NO. USED	MFRS CODE	GMC DWG NO.
P201, P203	CONNECTOR, RECEPTACLE, ELECTRICAL P/N 225-21521-101	2	71468	
P202	NOT USED			
P204	CONNECTOR, RECEPTACLE, ELECTRICAL P/N 225-21521-105	1	71468	
Q201-Q205	TRANSISTOR, TYPE 2N2222A	5	01295	
R201-R209	RES, FXD, COMP, 22K OHMS ±5%; STYLE RC07	9	81349	
R210-R215	RES, FXD, COMP, 4700 OHMS ±5%; STYLE RC07	6	81349	

Table 4.7

Manufacturers' Codes

CODE	MANUFACTURER	ADDRESS
01121	Allen Bradley Co.	Milwaukee, Wisc.
01295	Texas Instruments, Inc.	Dallas, Texas
02660	Amphenol Connector Div.	Broadview, Ill.
02735	Radio Corp. of America	Somerville, N.J.
04713	Motorola Semiconductor Products, Inc.	Phoenix, Ariz.
05820	Wakefield Engineering, Inc.	Wakefield, Mass.
07263	Fairchild Semiconductor Products, Inc.	Mountain View, Calif.
11236	CTS of Berne, Inc.	Berne, Ind.
11332	General Microwave Corp.	Farmingdale, N.Y.
12040	National Semiconductor Corp.	Danbury, Conn.
12517	Component Research Co. Inc.	Santa Monica, Calif.
14655	Cornell-Dubilier Electronics	Newark, N.J.
15636	Elec-Trol, Inc.	Saugus, Calif.
24138	International Electronic Corp.	Melville, N.Y.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
29083	Monsanto Co., Inc.	Santa Clara, Calif.
31433	Kemet Div. of Union Carbide Corp.	Greenville, S.C.
49956	Raytheon Co.	Lexington, Mass.
56289	Sprague Electric Co.	N. Adams, Mass.
65092	Weston Instruments, Inc.	Newark, N.J.
70903	Belden Corp.	Chicago, Ill.

Table 4.7 (Cont)

CODE	MANUFACTURER	ADDRESS
71468	ITT Cannon Electric	Santa Ana, Calif.
71590	Centralab Electronics Div.	Milwaukee, Wisc.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
72982	Erie Technological Products, Inc.	Erie, Pa.
73445	Amperex Electronics Corp.	Hicksville, N.Y.
74276	Signalite, Inc.	Neptune, N.J.
75915	Littelfuse, Inc.	Des Plaines, Ill.
79727	Continental-Wirt Electronics	Warminster, Pa.
80294	Bourns, Inc.	Riverside, Calif.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	Los Angeles, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
91637	Dale Electronics Inc.	Columbus, Nebr.

SECTION V - SCHEMATICS

This section contains the Model 467A Schematic Diagrams (5 sheets).

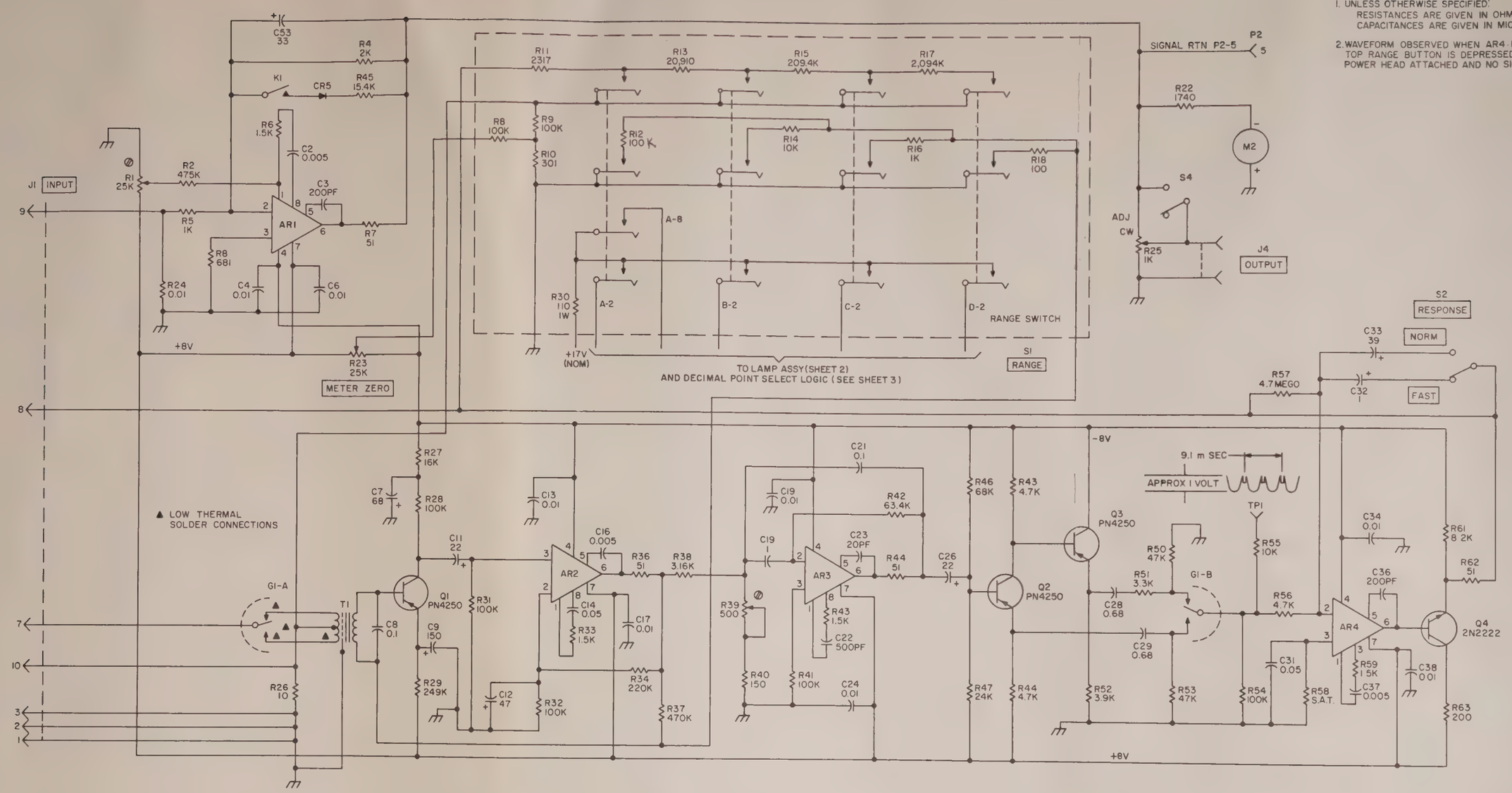


Figure 3.2 Model 467A Schematic Diagram (Sheet 1)

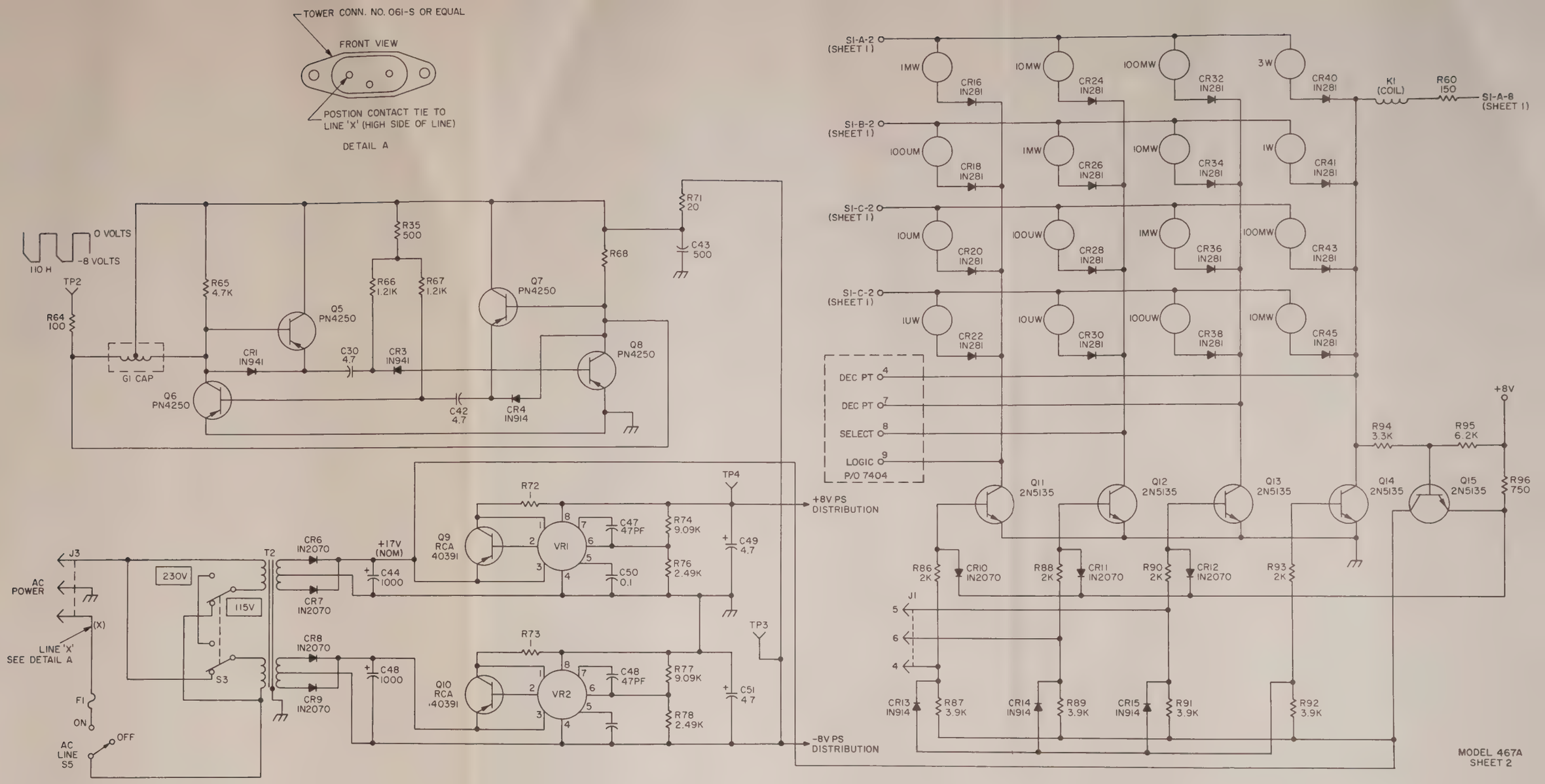


Figure 3.2 Model 467A Schematic Diagram (Sheet 2)

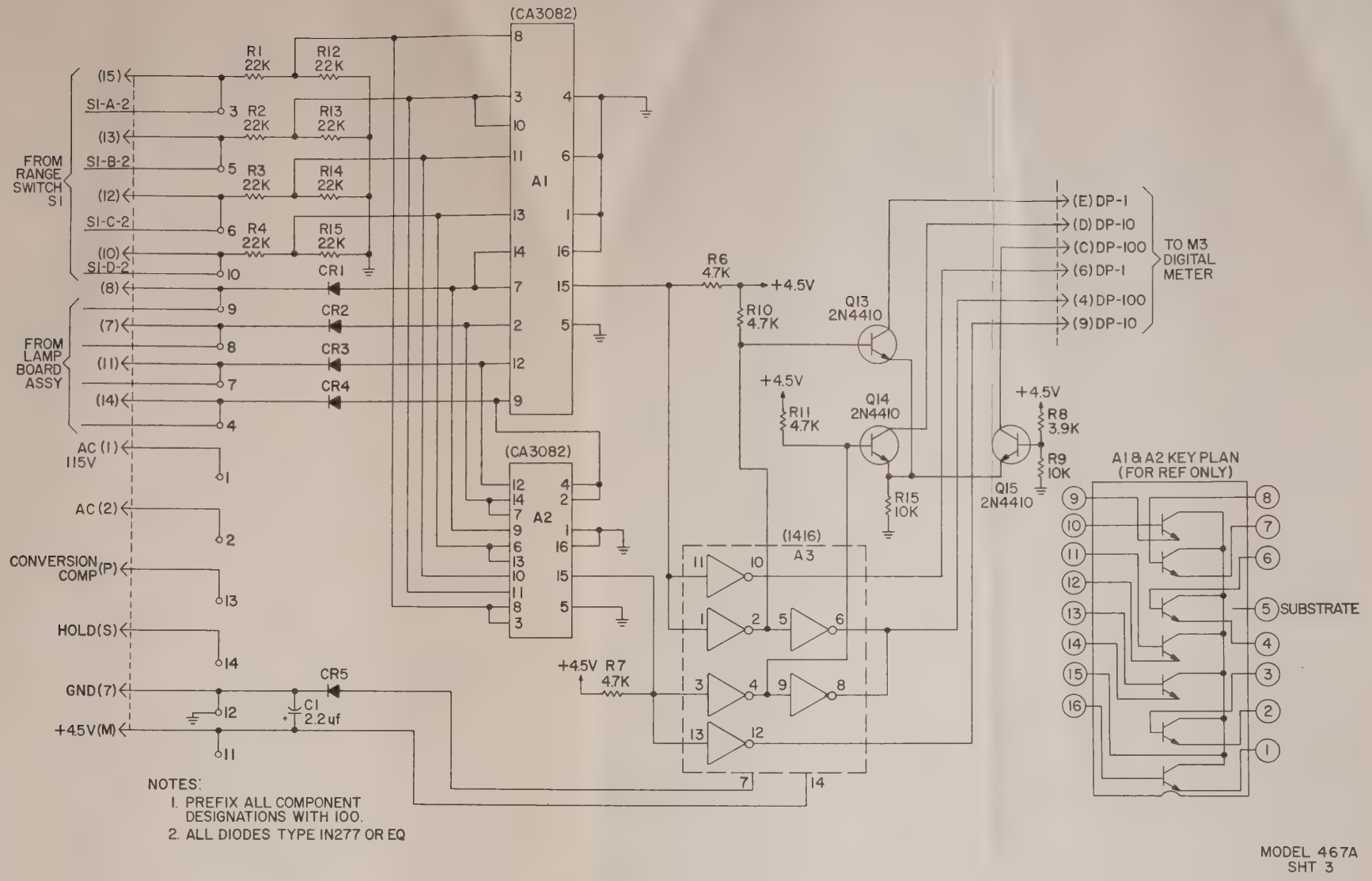
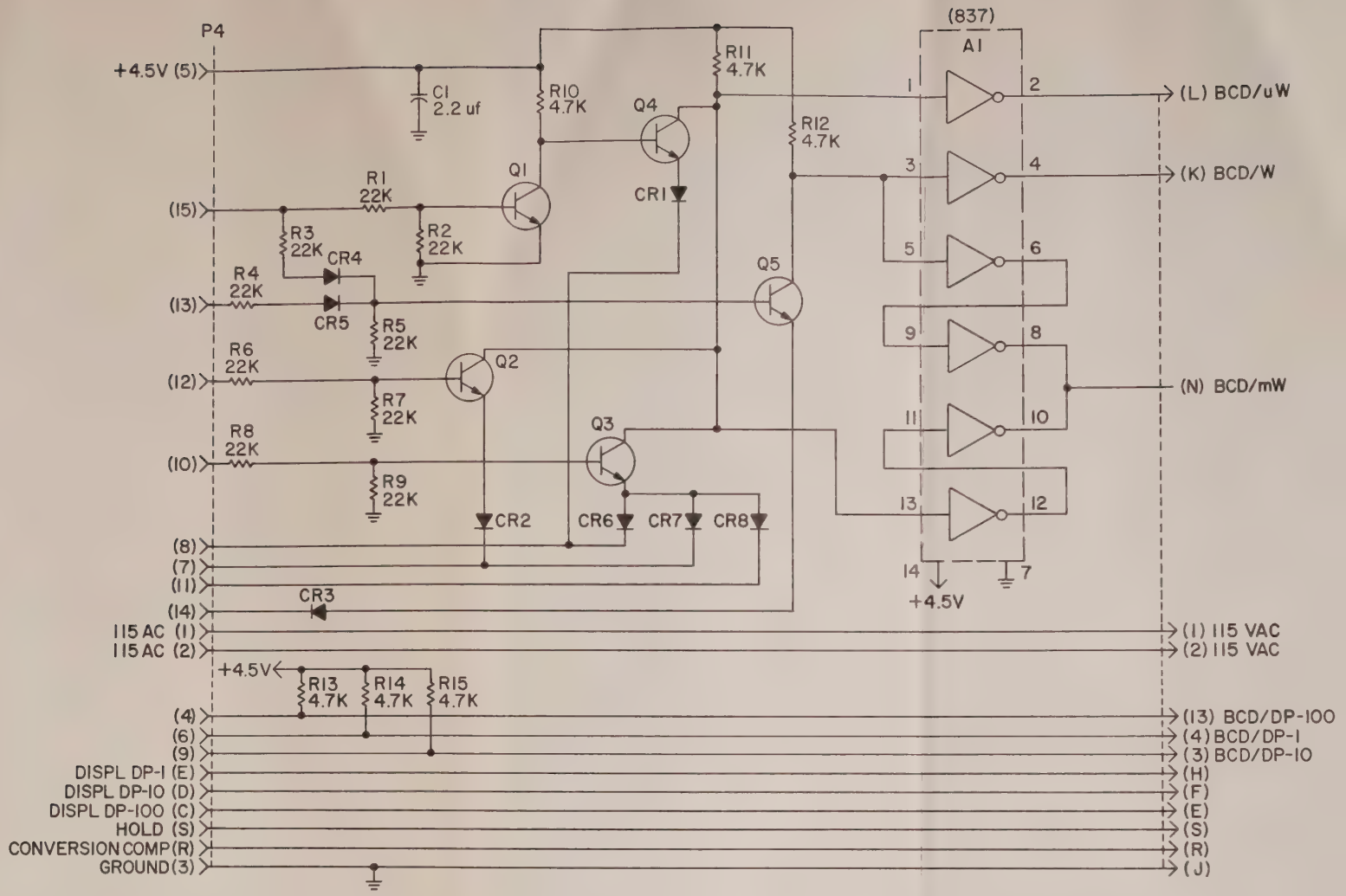


Figure 3.2 Model 467A Schematic Diagram (Sheet 3)



NOTES:

1. PREFIX ALL COMP. DESIGNATIONS WITH 200.
2. ALL DIODES IN277.
3. ALL TRANSISTORS TYPE 2N2222A OR EQ.

BCD LOGIC BD
SHT 4

Figure 3.2 Model 467A Schematic Diagram (Sheet 4)

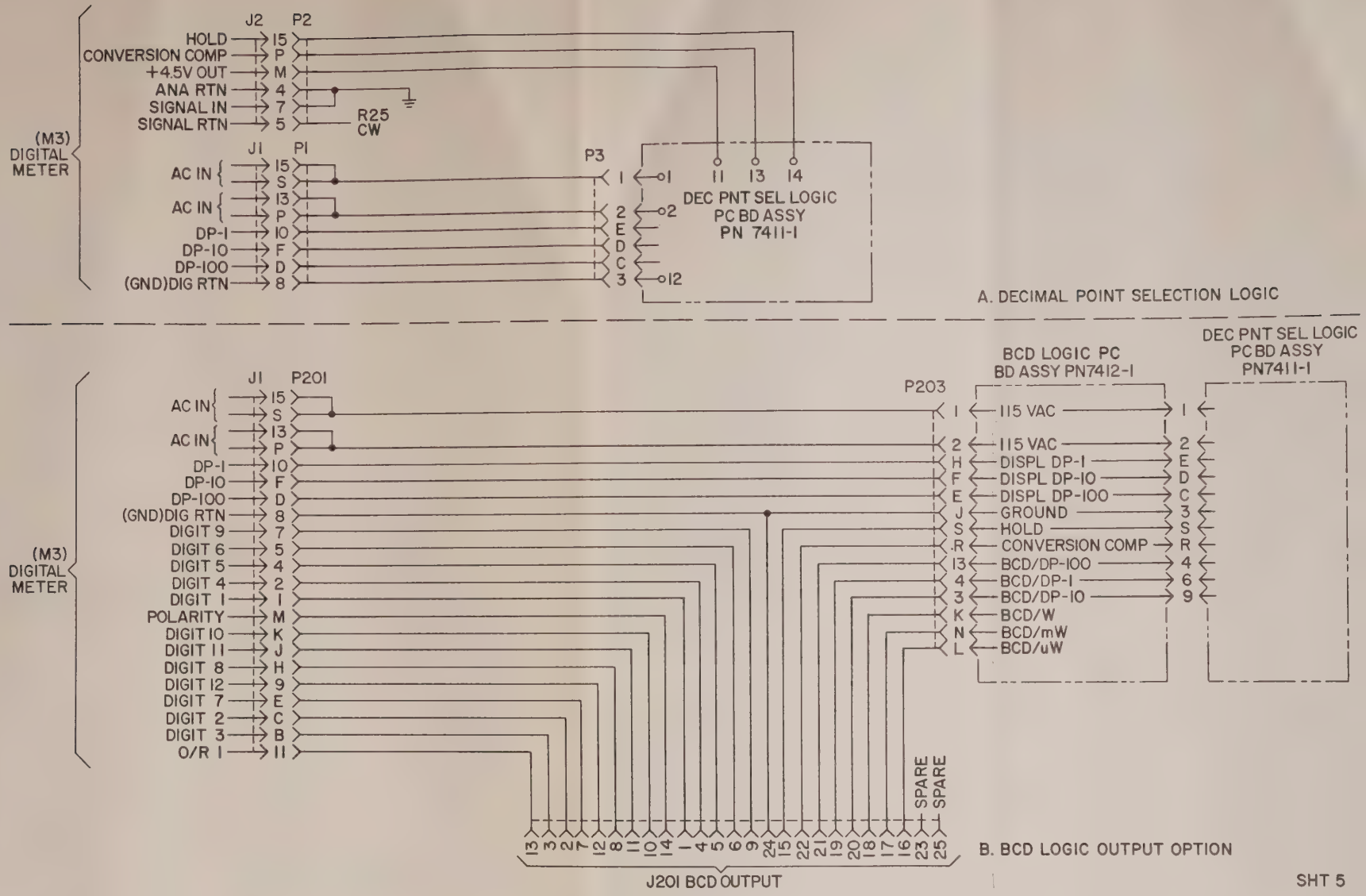


Figure 3.2 Model 467A Schematic Diagram (Sheet 5)

TABLE OF REPLACEABLE PARTS

Ref Sym	Description	P/N	Fed Mfr Code	Quantity Used Per Article		
				N420C	N421D	N422C
-	Screw, Minature*	4352H-10	11332	1	1	1
-	Washer*	3017D	11332	1	1	1
-	Cover Sheet, Front*	3155F-3	11332	1	N/A	1
-	Cover Sheet, Rear*	3155F-2	11332	N/A	1	N/A
-	Cover Sheet, Rear*	3155F-1	11332	1	N/A	1
-	Cable, Sp, Elec.	2978G	11332	5 ft.	5 ft.	5 ft.
-	Dial	4364E	11332	1	1	N/A
-	Dial	4363E	11332	N/A	N/A	1
-	Calibration Plate*	3928E	11332	1	1	1
C1, C2	Capacitor, Fxd, Ceramic; .01 uf ±20%, 100v	TG-S10	93561	2	2	2
C3	Capacitor, Fxd, Ceramic (Part of center conductor assembly)	3031C	11332	1	1	1
L1, L2	Choke, Rf, Fxd	3362D	11332	2	2	2
P1	Conn, Plug, Elec	2908C	11332	1	1	1
R1	Res, Fxd, Film 29.8Ω ±1%	RN60C29R8F	19701	1	1	N/A
R2	Res, Fxd, Film 18.2Ω ±1%	RN60C18R2F	19701	1	N/A	N/A
R2	Res, Fxd, Film 9.53Ω ±1%	RN60C9R53F	19701	N/A	N/A	1
R2	Res, Fxd, Film 191Ω ±1%	RN60C1910F	19701	N/A	1	N/A
R3	Res, Var, WW 100Ω	84-3-8-101	02111	1	1	1
R4	Res, Var, WW	4355B-1	11332	1	1	N/A
R4	Res, Var, WW	4355B-2	11332	N/A	N/A	1
RT1	Thermistor Assembly	4465C-1	11332	1	N/A	1
RT1	Thermistor Assembly	4465C-401	11332	N/A	1	N/A
-	tft Element	TL-0 A	11332	1	N/A	N/A
-	tft Element	TL-1 A	11332	N/A	1	N/A
-	tft Element	TL-2 A (see note below)	11332	N/A	N/A	1

* Also supplied with each replacement tft element.

ACCESSORIES AVAILABLE

Tool Kit TK-1 consisting of:

A. Assy Jig

B. Screwdriver

C. Tweezers

LIST OF MANUFACTURERS

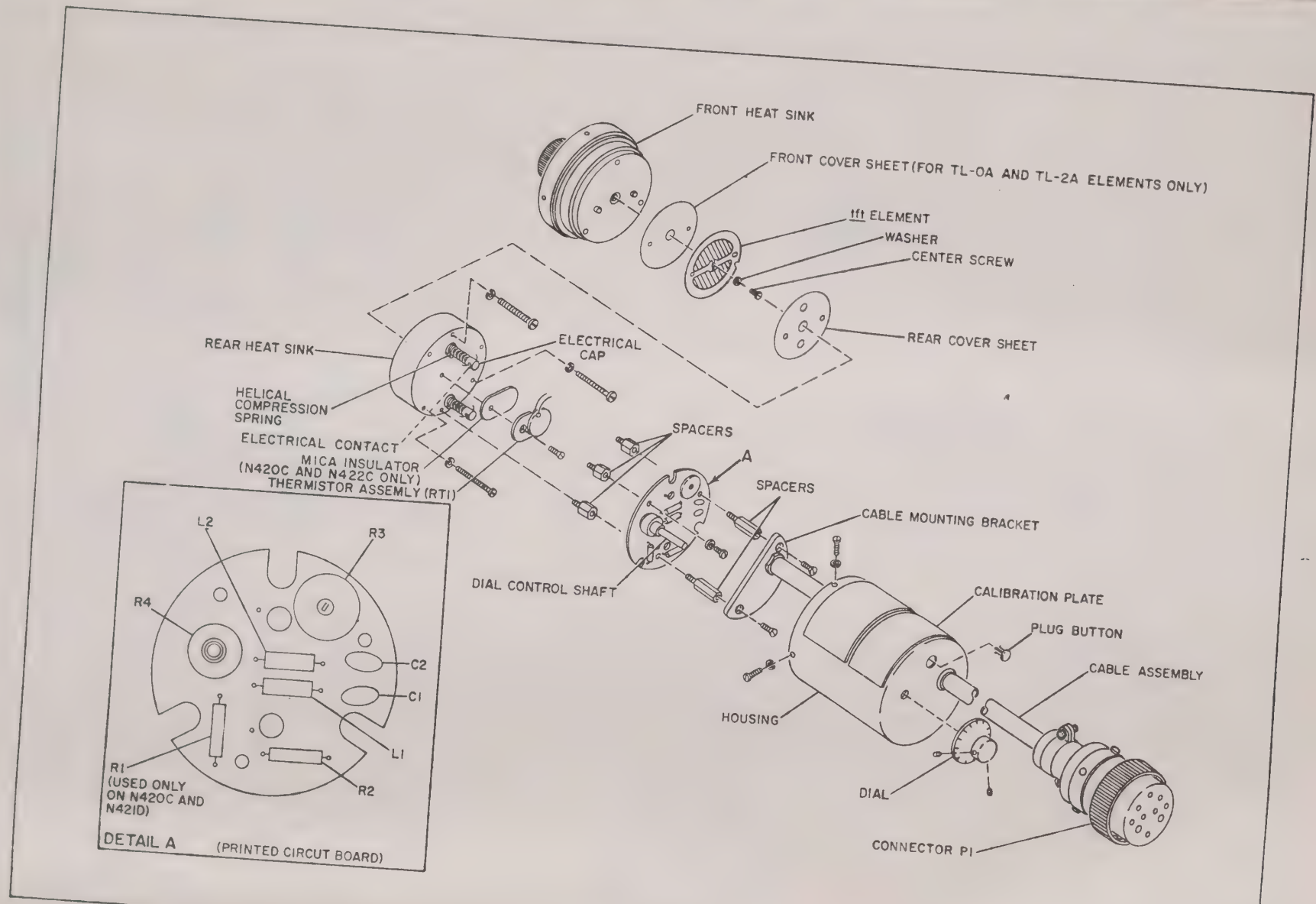
Code	Mfr
02111	Spectrol Electronics Corp., San Gabriel, Calif.
11332	General Microwave Corp., Farmingdale, N. Y.
19701	Electra Mfg. Co., Kansas City, Mo.
93561	Sprague Electric Corp., No. Adams, Mass.

NOTE

When ordering replacement tft elements for a Model N422C that is used with a cable length longer than the standard five-foot length, it is necessary to specify tft element numbers in accordance with the following data:

Cumulative Cable Length (feet)	tft element Model No.
0-10	TL-2A/2600
10-49	TL-2A/2700
50-99	TL-2A/2750
100-149	TL-2A/2800
150-199	TL-2A/2850
200-249	TL-2A/2900
250-299	TL-2A/2950
300-349	TL-2A/3000
350-399	TL-2A/3050

These data apply equally to Models N422C furnished with special cable lengths, and to standard Models N422C with five-foot cables that are used in conjunction with extension cable assemblies, such as GMC Models W967-( ), W970-( ) and W972-( ).


FRONT HEAT SINK
FRONT COVER SHEET (FOR TL-0A AND TL-2A ELEMENTS ONLY)
ELEMENT
WASHER
CENTER SCREW
REAR COVER SHEET
REAR HEAT SINK
ELECTRICAL CAP
HELICAL COMPRESSION SPRING
ELECTRICAL CONTACT
MICA INSULATOR (N420C AND N422C ONLY)
THERMISTOR ASSEMLY (RTI)
SPACERS
A
SPACERS
CABLE MOUNTING BRACKET
DIAL CONTROL SHAFT
CALIBRATION PLATE
PLUG BUTTON
CABLE ASSEMBLY
HOUSING
DIAL
CONNECTOR P1
L2
R3
R4
C2
C1
L1
R1 (USED ONLY ON N420C AND N421D)
R2
DETAIL A (PRINTED CIRCUT BOARD)

$$E_{DC}$$

$$E_L - \frac{1.5\,(E - E_L)}{200}\Big]$$

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from the formula:

$$\frac{}{s} (46.38\,S - 1)$$

s per watt and R_s is

N422C) Compute
lows:

$$E_{DC}$$

$$- \frac{1.5\,(E - E_L)}{200}\Big]$$

d value for the ca
om the formula:

$$- 0.103)$$

r the N420C, and
or the N422C

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P1 and adjust R3
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and attached to th

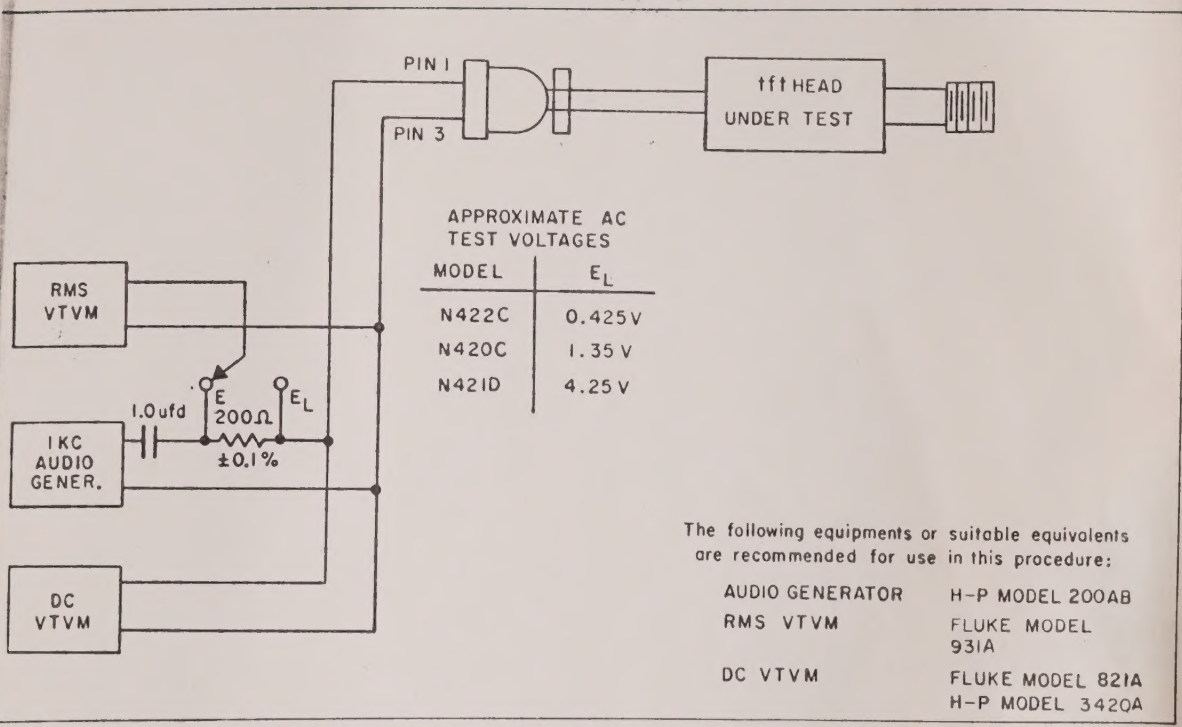

Figure 3. Test Set-Up for Audio Calibration

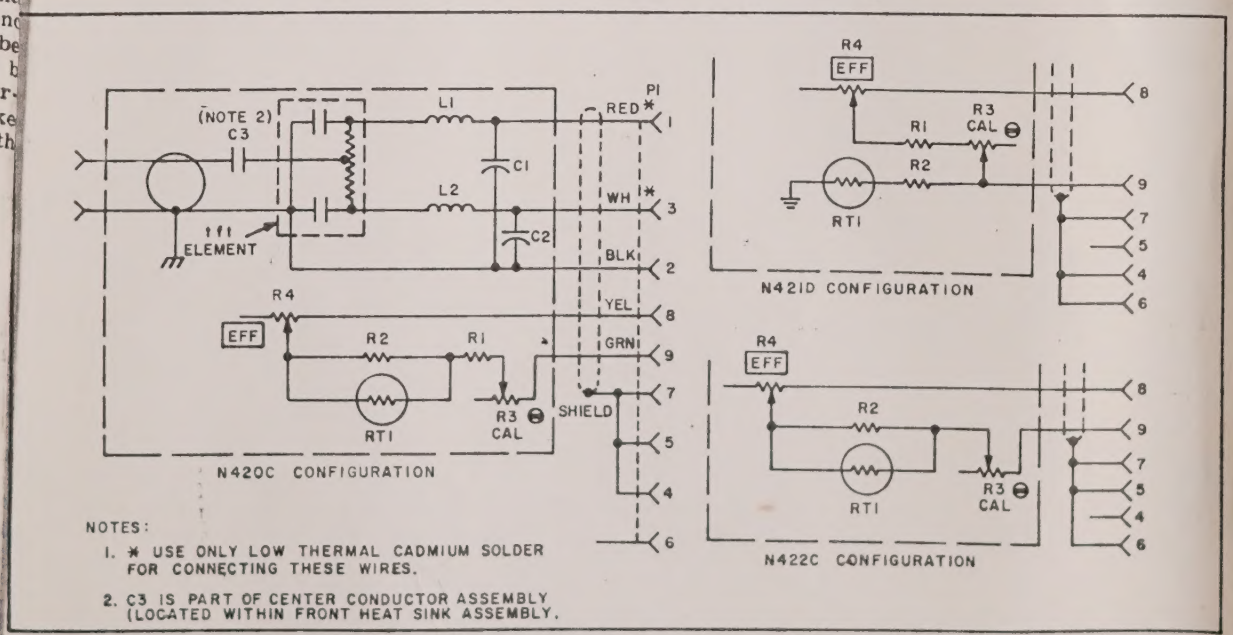

Figure 4. Schematic Diagram, Models N420C, N421D, N422C

MP MASTER
MA31504